ORIGINAL PAPER

DOI: 10.26794/2587-5671-2021-25-4-152-172
UDC 314.8(045)
JEL J11

Key Trends and Prospects for Sustainable Development of the Urban Settlement System in the Russian Federation

R.V. Fattakhov[a], M.M. Nizamutdinov[b] ✉, Yu.S. Aitova[c], V.V. Oreshnikov[d]
[a] Financial University, Moscow, Russia;
[b, c, d] Institute of Social and Economic Researches — Subdivision of the Ufa Federal Research Centre of the Russian Academy of Sciences, Ufa, Russia
[a] https://orcid.org/0000-0002-5863-7982; [b] https://orcid.org/0000-0001-5643-1393;
[c] https://orcid.org/0000-0001-8798-3078; [d] https://orcid.org/0000-0001-5779-4946
✉ Corresponding author

ABSTRACT

The subject of the study is the problem of the spatial distribution of the population in Russia and its regions. **The relevance** of research is determined by the key trends in the processes of distribution and movement of human capital in the context of cities. The paper **aims** to analyze the key trends and prospects for the development of the Russian settlement system at the federal, regional, and local levels. The research **methods** include a critical analysis of approaches to territorial settlement optimization, the modern system of urban settlement in Russia and its regions based on the use of statistical data of the Federal State Statistics Service for 2011–2019. The authors carried out a comparative analysis of the studied processes by countries using the Zipf method, as well as by Russian regions using the the Lorenz coefficient. It has been determined that the group of regions with an increase in the level of differentiation of urban settlement is characterized by a high level of depopulation of small and medium-sized cities with a contraction and concentration of the population in the largest city of the region, which creates additional risks for the sustainable development of the territory. A decrease in the level of differentiation of urban settlement is observed in regions where the share of the population of both small and medium-sized cities (but at a slower pace) and large ones is decreasing. **The scientific novelty** of the study lies in the development of an approach to improving the settlement system in Russia based on the application of the Lorenz coefficient and modelling methods. The authors **conclude** that an uneven system of settlement has developed in Russia, creating prerequisites for the emergence of new imbalances and threats to the complex sustainable development of the country's territory. In this regard, it is advisable to develop an appropriate document in the field of state policy at the federal level or clarify similar issues within the framework of existing documents, as well as to increase the scientific validity of the measures taken using formalized methods of forecasting and planning. A promising direction in this area is the development of an agent-based model that allows increasing the efficiency of the distribution of financial resources for the development of social infrastructure. **The results** of the study justify the expediency of reallocating financial resources of the budget to ensure state policy in the field of development of the settlement system in the country.
Keywords: settlement system; Russian regions; social infrastructure financing; Zipf curve; Lorenz coefficient

For citation: **Fattakhov R.V., Nizamutdinov M.M., Aitova Yu.S., Oreshnikov V.V. Key trends and prospects for sustainable development of the urban settlement system in the Russian Federation.** ***Finance: Theory and Practice.*** **2021;25(4):152-172. DOI: 10.26794/2587-5671-2021-25-4-152-172**

INTRODUCTION

One of the urgent problems both for the world community and for individual countries is the spatial population distribution and the influence of demographic processes on the sustainability of the development of territories. The implementation of measures aimed at managing these processes requires significant financial resources from the state and private companies. In the Russian Federation, in the context of increasing urbanization, the main demographic trends are the concentration of human capital in the most developed and large settlements, which are the economic and financial centers of the country, the uncontrolled growth of agglomerations, the deterioration of the socio-economic situation of medium and small-sized cities, a significant migration outflow from most territorial formations, rural degradation, etc. All this creates risks of loss of sustainability in the development of both individual settlements and entire regions of the country. At the same time, we are talking not only about territories that are losing human capital, but also about the largest cities of the country, the load on the social infrastructure of which is increasing every year. In this regard, the optimization of resettlement, the achievement of sustainable, uniform socio-economic development of territories of different levels due to the rational distribution of human capital, including by adjusting the structure of expenditures of budgets of all levels, are becoming important development issues of state policy of Russia in the field of spatial development.

The aim of this study is to analyze the key trends and prospects for the development of the settlement system in Russia both at the federal and regional levels. In order to achieve this goal, it is necessary to analyze the system of urban settlement in Russia and its regions, the priorities of state management of spatial development, scientific approaches to optimizing territorial settlement, the peculiarities of financing the social infrastructure of territories as a key factor in their demographic development, as well as ensuring the stability of the settlement system as a whole [1]. Based on the results of the analysis, it is planned to identify the main trends and directions of the development of the settlement system in Russia.

METHODOLOGICAL APPROACHES TO REGULATION OF THE SETTLEMENT SYSTEM DEVELOPMENT

In the scientific community, a settlement system is a subject of interest in the framework of research in the field of demography, economics, sociology, geography, etc. [2–4]. There are various approaches to understanding the settlement system, which in most cases boil down to its definition as a set of settlements on a territory with such properties as the presence of regular transport inter-settlement connections, certain central places that perform system-wide functions to meet the needs of the population [5]. Thus, the settlement system is a group of settlements interacting with each other [6]. The main elements of the settlement system are settlements and population [7]. An important aspect of state regulation at various levels of the territorial organization is the regulation of the settlement system to increase the level of balanced spatial population distribution. The issues of sustainable development of territories, including from the standpoint of demographic sustainability, are discussed in the works of A.V. Antyufeev, O. O.M. Roi, I.D. Turgel', T.V. Maleeva, and others.

Currently, Russian scientists have developed a number of approaches to optimizing the settlement system in the conditions of Russian reality, their list is

presented in the *Table 1*. It should be noted that this list is not exhaustive, including but not limited to the existence of various combinations of these approaches.

The considered concepts of settlement systems can be conditionally divided into those involving the development of territories of various levels (the concept of GSS, the concept of a unified settlement system) and based on point development (the concept of polarized development, the concept of agglomerations of accelerated development, etc.). In addition, it should be noted that the closest to the modern realities of Russian reality is the concept of GSS, within the framework of which the existing system of settlement took place.

Currently, there is no concept of a balanced settlement system in official documents of Russia at the state level. However, in domestic studies devoted to the issues of the spatial distribution of the population in the 80s, the "balanced system of settlement" was defined as "the rational distribution of productive forces, taking into account the need and availability of labor resources, specialization of the territory, which makes it possible to achieve a decrease in the degree of differentiation of the population of different territories, the organization of public space to ensure a comfortable life for the population, opportunities for the integrated development of human capital, improve transport accessibility between territories, etc.".1 An important goal of Soviet policy in the field of improving the system of population settlement was designated "assistance to increase the stability of the functioning of the national economic complex of the country".

Improving, achieving a balance of the settlement system, and ensuring its sustainability is currently not included in the number of the main priority areas of state policy formulated by the President of the Russian Federation in 2018. Nevertheless, among the existing federal regulatory documents, some are devoted to the issues of the spatial distribution of the population in the country, which include:

- General scheme of settlement on the territory of the Russian Federation (basic provisions)2;
- Strategy for the spatial development of the Russian Federation for the period up to 20253;
- Concept of the state migration policy of the Russian Federation for 2019–2025.4

From the point of view of considering the priority directions of the state's activity in the field of resettlement, the prevalence of the trend of polarized development (mainly focusing on certain territorial systems) can be noted. Such a development option can to a greater extent contribute to the increasing dynamics of population pulling into large economic centres and the desertion of many territorial entities, which, in turn, will violate the country's integrity, affect the sustainability of urban development and threaten national security. Thus, despite the developed documents, a number of unresolved issues remain in this area [12]. In these circumstances, in our opinion, it is necessary to clarify the priority directions of the development of the settlement system to achieve the most even territorial development. An important stage in their

[1] Settlement Modeling Guide. Central Research Institute of Urban Development Gosgrazhdanstroy. M.: Stroyizdat; 1982. p. 144.

[2] "General scheme of settlement on the territory of the Russian Federation (basic provisions)", approved by the Government of the Russian Federation. Minutes dated 15.12.1994 No. 31. URL: https://docplan.ru/Data2/1/4294855/4294855147.pdf (accessed on 01.06.2021).

[3] Order of the Government of the Russian Federation dated February 13, 2019, No. 207-r "On approval of the Strategy for the spatial development of the Russian Federation for the period up to 2025". URL: http://www.consultant.ru/document/cons_doc_LAW_318094/ (accessed on 01.06.2021).

[4] Decree of the President of the Russian Federation of October 31, 2018, No. 622 "On the Concept of the State Migration Policy of the Russian Federation for 2019–2025". URL: http://www.consultant.ru/document/cons_doc_LAW_310139/ (accessed on 01.06.2021).

Table 1

Approaches to optimization of the Russian settlement system

Authors	Concept	Main points
O.K. Kudryavtsev, V.V. Vladimirov and others [8]	The concept of group systems of settlements (GSS)	Centre-periphery system, city-centres, and satellite cities. The socio-economic system of the central city must be sufficient for the base of the city's residents and the population of the entire region, it is necessary to develop transport networks. Developed within the framework of the USSR settlement scheme. In group settlement systems, each city or village is not as an economically isolated unit, but as part of this system, for which the national economic planning is intended to perform certain production and labor functions.
D.G. Khodzhaev, B.S. Khorev, G.M. Lappo and others [9]	The concept of a unified settlement system. Settlement support frame	A unified system of settlement implies the formation of a state policy, according to which urban and rural settlements "should not differ significantly in terms of living conditions, living standards and services, and also equal living conditions in cities of various sizes and the most rational spatial population distribution should be ensured. In addition, it is proposed to limit the growth of large cities with the simultaneous development of small and medium-sized ones. The settlement support frame expresses the hierarchy of the constructed aggregate of settlements of different levels"
I.G. Lezhava [10]	Linear settlement concept	The linear settlement system assumes settlement along the main transport corridors. The author, relying on the importance and role of the creation of the Trans-Siberian Railway, proposes the regulation of settlement by creating a similar transport network. "The central axis of the channel is a system of transport and rail routes along the Eurasian channel from West to East with three transverse branches from North to South"
E.F. Mavlyutov, G.S. Yusin, Yu.V. Raev [5]	Polarized development. Unified settlement system	They offer 2 options for solving the existing problems of settlement: polarized development and a unified settlement system. Polarized development allows us to focus on the potential of already emerging centers of economic growth, the formation of centers of advanced development in the northern regions. The unified settlement system is the provision of general socio-economic development and equal conditions for the economic growth of various urban and rural areas in order, among other things, to preserve the cultural heritage and diversity of the Russian Federation
A.G. Mazaev [11]	The concept of accelerated development agglomerations	The main idea of the approach is to curb the growth of Moscow during the development and enlargement of cities with a million-plus population and their agglomerations, which are on the list after St. Petersburg until the population level is reached according to Zipf law

Source: compiled by the authors.

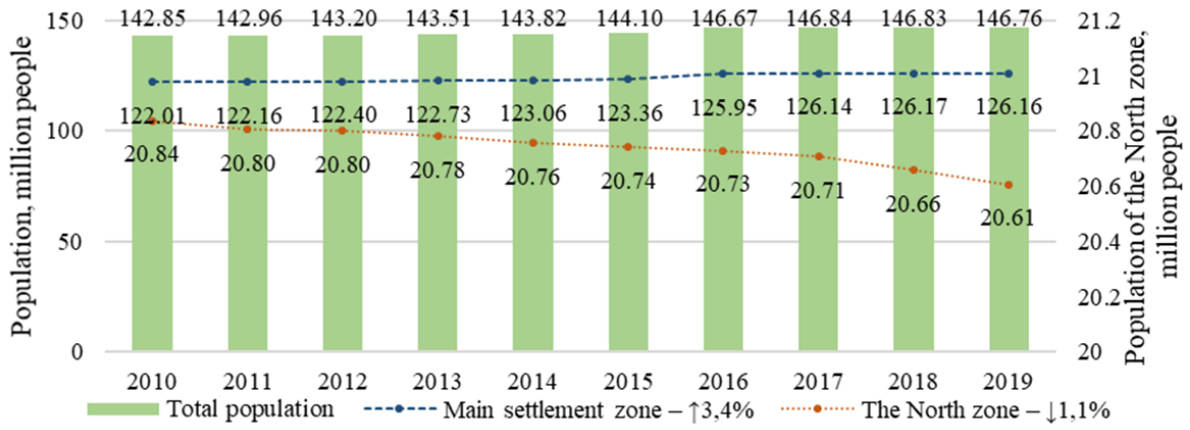

Fig. 1. **Population dynamics of the country, of the main band of settlement and the North zone, with the Republic of Crimea and Sevastopol**

Source: compiled by the authors based on data of the Federal State Statistics Service. URL: https://rosstat.gov.ru/folder/12781 (accessed on 22.02.2021).

determination is the analysis of the current situation in the sphere of resettlement in Russia.

FEATURES OF URBAN SETTLEMENT IN RUSSIA

Russia is one of the states with a low population density and a high degree of unevenness in its distribution. It should be noted that the modern settlement system was significantly influenced by the historical features of the country's development. As a result, today they distinguish between the main zone of settlement (MZS) and the peripheral zone, mainly the territory of the North. MZS is characterized by a population density higher than the Russian average, i.e. more than 8.6 people for 1 sq. km of territories. Mainly MZS is localized on the territory of the Central, North-West, South, North-Caucasian, Volga, Ural Federal Districts, except for several regions (Murmansk, Arkhangelsk regions, the Republic of Karelia, the Komi Republic), but includes Omsk, Novosibirsk, Kemerovo regions, The Republic of Khakassia and the Altai Territory. The main zone of settlement occupies only 22% of the total area of the country's territory and concentrates about 85% of the total population. The key financial and economic centers of the country are also located here.

For the period 2010–2019, the population living in the MZS within the borders of Russia in 2010 increased by 1.5%, while the rest of the population is decreased by 1.1%. Considering the Republic of Crimea and Sevastopol, the population size within the main zone of settlement increased by 3% (*Fig. 1*).

Russia is one of the countries with a high level of urbanization; three- quarters of the country's population live in cities. Within the main zone of settlement of Russia, the urban population reaches 65%.5 These territorial entities in the modern world are becoming the main centres for the development of the economy, industry, human capital, social infrastructure, a comfortable living environment, etc.

According to the Code of Rules6 all cities in Russia are divided by population into extremely largest, very large, large, medium, small (urban-type settlements belong to small cities; large cities are represented by two categories).7 The structure of the urban

[5] Rosstat (2021). The share of the urban population in the total population as of January 1, 2020. URL: https://showdata.gks.ru/report/278932/ (accessed on 22.03.2021).

[6] The Code of Rules 42.13330.2016 "Urban planning. Planning and development of urban and rural settlements. URL: https://docs.cntd.ru/document/456054209 (accessed on 15.02.2021).

[7] Rosstat (2021). The population of the Russian Federation by municipalities, 2011–2019 Official site of the Russian

Table 2

Structure of the distribution of the urban population by city type in Russia (at the beginning of the year), %

City type (depending on the size of the population)	Year			
	2010	2013	2016	2019
1 million +	27.4	32.5	32.5	32.8
500,000–1 million	16.3	12.8	12.7	13.3
250,000–500,000	12.8	13.5	14.9	14.3
100,000–250,000	14.9	14.1	13.5	13.9
50,000–100,000	11.1	10.6	10.6	10.2
Under 50,000	17.6	16.5	15.8	15.5

Source: compiled by the authors based on data of the Federal State Statistics Service. URL: https://rosstat.gov.ru/compendium/document/13282 (accessed on 22.02.2021).

population of the country depending on the size of the city is presented in *Table. 2*.

In general, for the period 2010–2019, there is an increase in the share of the urban population living in the largest cities of the country. At the same time, at the beginning of 2010, there were 11 cities with a population of one million, whereas since 2013 their number has increased to 15.8 The share of the population of very large cities decreased to a greater extent due to the transition in 2013 of Krasnoyarsk, Voronezh, Perm, and Volgograd to the category of the very large cities. During the period under review, the share of large cities with a population of 250–500 thousand people increased due to the addition of four territories to this category (Podolsk, Novorossiysk, Yoshkar-Ola, and Khimki). It should be noted that the share of the population living in cities with a population of 100–250 thousand people decreased to 13.9%, despite the increase in the number of cities in this category. The same situation is typical for small and medium-sized cities in the country. These settlements tend to lose demographic stability since the migration outflow of the population from them primarily covers the most active working-age population of fertile age. It is noteworthy that demographic and financial processes are interdependent. Thus, an increase in the population of the extremely large cities makes them "richer" by receiving a larger volume of tax and non-tax revenues to the budgets, increasing investment attractiveness, and increasing the level of income of the population. At the same time, due to economic development, the migration attractiveness of these territories increases, the availability of better-quality health care services, an increase in life expectancy, etc. For small cities, exactly the converse situation is observed.

The bulk of the urban population is concentrated in one of the largest cities, at the regional level in 55 out of 85 constituent entities. At the same time, the most populated territories are of different sizes. In most cases (in 30), the largest city is considered with a population of 250 to 500 thousand people. In 19 constituent entities of the Russian Federation, these are very large cities, in 15 regions —cities with million-plus population, in 14 — cities with a population of 100 to 250 thousand people, in 4 — from

Statistical Agency. URL: https://rosstat.gov.ru/compendium/document/13282 (accessed on 22.03.2021).

[8] Rosstat (2021). The population of the Russian Federation by municipalities, 2011–2019 Official site of the Russian Statistical Agency. URL: https://rosstat.gov.ru/compendium/document/13282 (accessed on 22.03.2021).

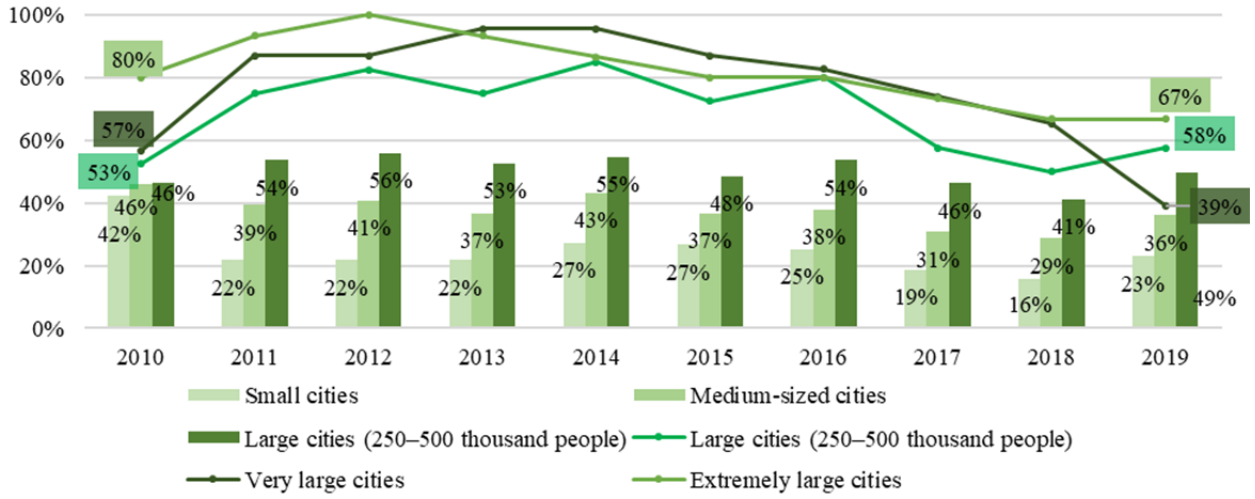

Fig. 2. **Share of Russian cities in the size group with population growth (compared to the previous year)**

Source: compiled by the authors based on data of the Federal State Statistics Service. URL: https://rosstat.gov.ru/compendium/document/13282 (accessed on 22.03.2021).

50 to 100 thousand people, in 3 — under 50 thousand people.

Remarkably, the dynamics of the population size within each group are significantly different. Thus, the population in cities with a population of one million over the period under review increased by 14% (by 4.2 million people in absolute terms), in cities with a population of 250 to 500 thousand people — by 9% (1.2 million people), in cities with a population of 100 to 250 thousand people — by 4% (by 518.8 thousand people), while the population of medium and small-sized cities decreased by 3% (by 330.4 and 508.1 thousand people, respectively). *Fig. 2* shows the proportion of cities in each group that has seen an increase in population compared to the previous year.

It should be noted that for all groups, with the exception of very large and large (with a population of 250 to 500 thousand people), a decrease in the share of cities in which there has been an increase in population is characteristic. If in 2010, 42% of small cities experienced population growth, then in 2019 this share decreased by almost half (to 23%), thus depopulation of the population and an increase in the risk of loss of demographic stability are characteristic of the majority of small cities.

Thus, the key trends in the development of urban settlements in Russia are the concentration and reduction of the bulk of the population in the extremely large and very large cities of the country, as well as a high level of outflow from medium and small-sized cities. The same dynamics continue at the regional level. Given the large territory of the country, the presence of various climatic zones, unfavorable territories, but strategically important from an economic point of view, the formation and strengthening of such a settlement system, which would make it possible to achieve the most even and balanced distribution of the population, taking into account the expedient need for human capital, plays a special role. The modern socio-economic state of urban settlements is characterized by a high level of differentiation of the socio-economic development of territorial entities of different types. Moreover, this polarization of territories is increasing, which ultimately leads to the outflow of a significant part of the active population and the gradual degradation of settlements. These circumstances contribute to the development

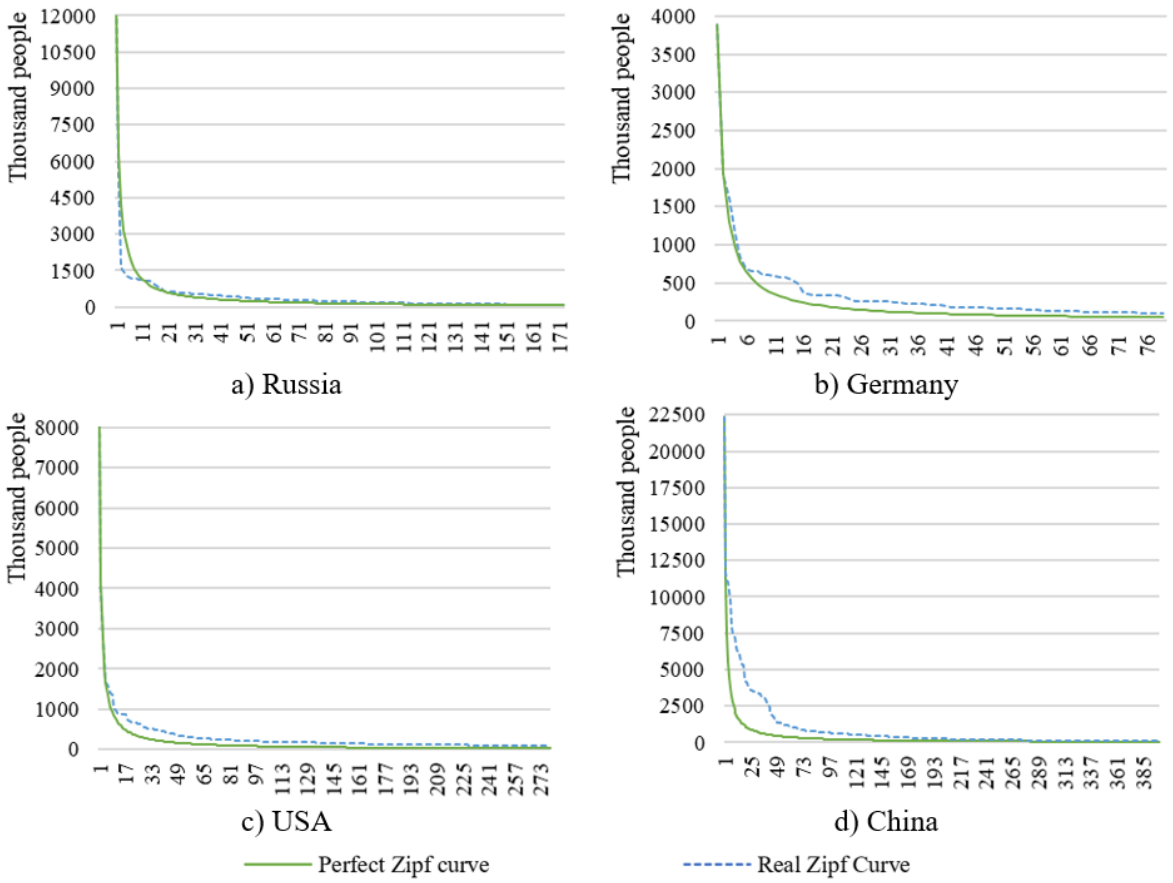

Fig. 3. **Zipf curves for cities with a population of more than 100 thousand people by countries**

Source: compiled by the authors based on data of the Federal State Statistics Service, World Population Review for Germany, USA, China. URL: https://rosstat.gov.ru/compendium/document/13282; https://worldpopulationreview.com/countries/cities/germany; https://worldpopulationreview.com/us-cities; https://worldpopulationreview.com/countries/cities/china (accessed on 22.03.2021).

of the state policy measures in the field of optimizing the national settlement system developing various territories and increasing the level and quality of life of the population, etc. In this case, the objective need is to determine the level and dynamics of differentiation of urban settlements of the country and regions, to identify crisis, problem areas, and ways to improve the current situation. This requires significant financial resources.

ANALYSIS OF URBAN POPULATION DISTRIBUTION IN RUSSIA

The most commonly used method for determining the correspondence of the distribution of the urban population of a country to the "perfect" variation is the Zipf curve (Zipf coefficient). This approach is based on calculating a logarithmic equation that considers the size of the population and the rank of the city [13–15]. According to Zipf law, "the distribution of cities by population is subject to the "rank-size" or "power law" model [16], that is, when ranking cities by population, the ratio of the number of two cities will be inversely proportional to the ratio of their ranks" [14]. Zipf curves for Russia, Germany, the USA, and China are shown in *Fig. 3*. The graph shows that the real Zipf curve differs from the "perfect" distribution of cities by population. In the reference version for Russia, the next city after St. Petersburg has to be a city with a population of 4.2 million, followed by 3.2 million etc. [17].

China, the United States, and Germany were considered in the comparative assessment as

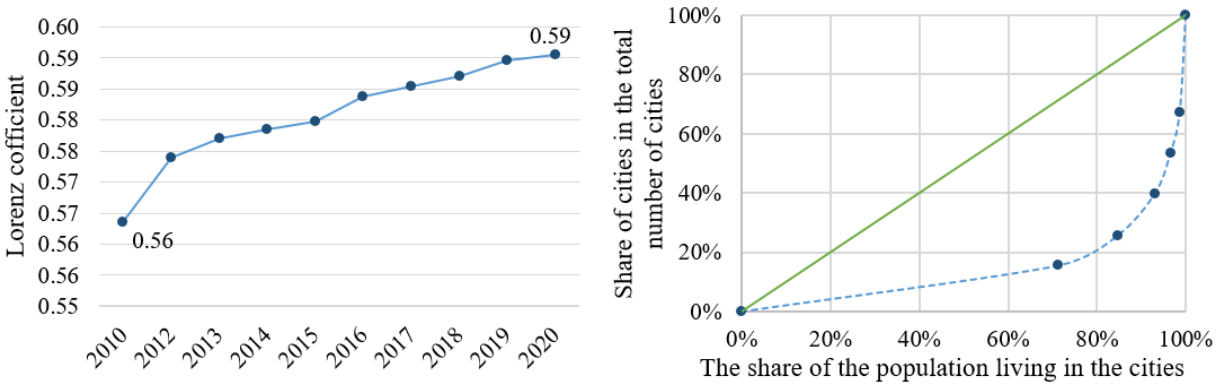

Fig. 4. **Dynamics of the Lorenz coefficient for the period 2010–2020 (left) and the Lorenz curve for the Russian urban settlement system for 2020 (right)**

Source: compiled by the authors based on data of the Federal State Statistics Service. URL: https://rosstat.gov.ru/compendium/document/13282 (accessed on 22.03.2021).

countries with large populations. The analysis was carried out in the context of 400 cities in China, 279 cities in the USA, 173 cities in Russia, 79 cities in Germany with a population of more than 100 thousand people. The real Zipf curves for China, the United States, and Germany are higher than perfect, which is typical for countries with a high population density and a large number of cities. On the graph of Russia, the real Zipf curve is at the beginning lower than the perfect one, which is more typical for developing countries, the rest of the real curve is higher than the reference one, which corresponds to the population distribution in developed countries. Scientists explain this effect by the vast territory of the country and the high level of differences in social, economic, natural, and climatic conditions.

As a rule, the Zipf method is recommended to be used to analyze on the basis of the list of the country's largest cities [18]. Considering that its application for a greater level, for example, for regions, does not allow to obtain adequate results. In this case, to assess the distribution of the population in the territories of a smaller scale under comparison, as well as the definition of trends, the dynamics of changes are possible to use the Lorenz concentration curve. This method is more known as a method for assessing the distribution of income between population groups to identify and determine the degree of inequality. In the case of absolute equality, the Lorenz curve takes the form of a diagonal straight line (every 20% of the population is obtained 20% of income), while with absolute inequality — the type of vertical direct (1% of the population is obtained by 100% income). If this approach is used to analyze the uniformity of the distribution of urban population in the regions, the share of the population living in a particular group of cities will appear, and the share of this group of cities in their total quantity for the region. The Lorenz concentration coefficient varies from 0 to 1, where 0 is absolute equality (uniform distribution of the population by type of cities of the region), and 1 is an absolute inequality (in this case, the concentration of the population in one territorial education). The formula for calculating the coefficient to assess the distribution of urban population is presented below [19, p. 246].

$$C_L = \frac{\sum |d_i - q_i|}{2},$$

where C_L — Lorenz concentration coefficient;

d_i — share of cities of the i-th category in the total number of cities;

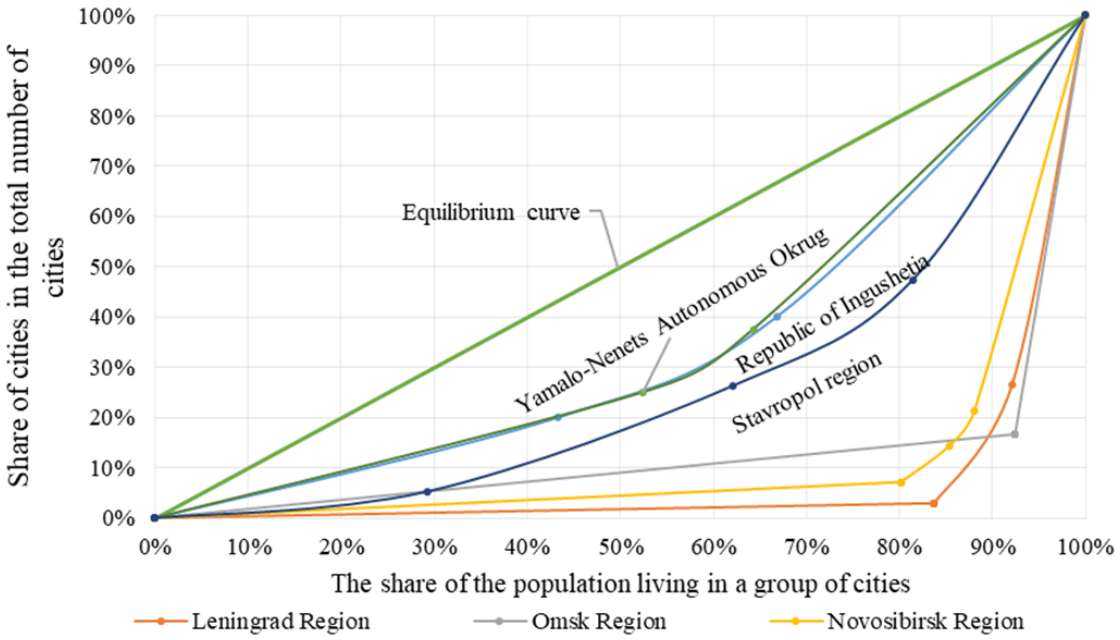

Fig. 5. **Lorenz curve for the first and last three regions by the uniformity of urban settlement**

Source: compiled by the authors based on data of the Federal State Statistics Service. URL: https://rosstat.gov.ru/compendium/document/13282 (accessed on 22.03.2021).

q_i — share of the population living in cities of the i-th category in the total number of residents.

It should be noted that a certain disadvantage of using this method in relation to the indicated indicators is that the coefficient does not allow considering the absence of entire groups of cities in the region. At the same time, this method can be useful for identifying trends in the distribution of the population across the cities of the region.

Fig. 4 shows the dynamics of the Lorenz coefficient for Russia, as well as the Lorenz curve for the country's settlement system at the beginning of 2020.

The results of the analysis show that over the past 10 years in Russia, the Lorenz concentration coefficient has increased from 0.56 to 0.59, which characterizes an increase in the level of differentiation of urban settlement. To a greater extent, this dynamic is due to the increase in the share of the population living in the largest and large cities, while its decrease is in small and medium-sized ones.

It seems interesting to test this hypothesis at the regional level. To achieve this goal, similar calculations were carried out based on data from official statistical collections on the population of cities and the number of cities in the regions of Russia for the period 2012–2020. The choice of the time interval is due to the peculiarities of the presentation of statistical data in the publicly available (information is indicated at the beginning of the year, excluding urban-type settlements).[9] The regions excluded from the analysis should be noted: the Nenets Autonomous Okrug, the Republic of Adygea, the Republic of Kalmykia, the Altai Republic, the Kamchatka Territory, the Magadan Oblast, the Jewish Autonomous Oblast, the Chukotka Autonomous Okrug, as well as the Republic of Crimea, and Sevastopol. Such a list of subjects is due to such reasons as a small number of cities (less than 3) in the composition of a subject or insufficient

[9] Rosstat (2021). The population of the Russian Federation by municipalities. 2011–2019 Official site of the Russian Statistical Agency. URL: https://rosstat.gov.ru/compendium/document/13282 (accessed on 22.03.2021).

data for the analyzed period (the Republic of Crimea and Sevastopol). Moscow and Leningrad regions include Moscow and St. Petersburg, respectively, since these cities are actually the economic centers of these entities.

Based on the calculations obtained, a rating of regions was compiled by the value of the Lorenz coefficient at the beginning of 2020. The following graph shows the Lorenz curves for the first three and last regions in this ranking (*Fig. 5*). The closer the Lorenz curve for the region's settlement system is to the equilibrium line, the more evenly the population is distributed over a given subject.

As of the beginning of 2020, the Republic of Ingushetia, the Yamalo-Nenets Autonomous Okrug and the Stavropol Region are closest to an even distribution of the population by categories of cities. The concentration ratios in these cases were 0.26, 0.27 and 0.36, respectively. A distinctive feature of these regions is that less than 52% of the total urban population of the region lives in the largest cities, and the most densely populated cities are large. So, for example, at the beginning of 2020, there were five cities in Ingushetia — Magas (12.2 thousand people), Malgobek (38.6 thousand people), Karabulak (42.7 thousand people), Sunzha (66.3 thousand people) and Nazran (122.3 thousand people).10 The first three cities are classified as small with a total population of 93.5 thousand people. (33% of the total population of the region). Sunzha, being a medium-sized city, concentrates almost a quarter of the entire population of this subject of the federation. The largest city in the region is Nazran, which in 2010–2012 also belonged to the category of medium-sized cities, but in 2013 it moved to the category of large ones. Earlier, in 2001–2009, this city also belonged to the category of large cities, but from July 1, 2009, the Barsukinsky and Plievsky districts were abolished, removed from its structure as the villages of Barsuki (10.3 thousand people) and Plievo (13, 7 thousand people) were returned to the Nazran region. Currently, 43% of the region's population lives in Nazran. Thus, largely due to the indicated change in the status of the city of Nazran in comparison with the base year 2012, the distribution of the population according to the Lorenz coefficient has become more even.

At the same time, Novosibirsk, Omsk, and Leningrad regions are far from even urban settlement, the concentration coefficients here were 0.73, 0.75, 0.80, respectively. In these regions, more than 77% of the urban population is concentrated in the largest city with a population of over one million. In general, it should be noted that out of 10 regions with a high value of the Lorenz coefficient, which characterizes a significant level of uneven distribution of the population, 6 are "owners" of a municipality with a population of more than 1 million people.

Considering the dynamics of the concentration coefficient by region for 2010–2020, it can be noted that 80% of the subjects participating in the analysis are characterized by an increase in the differentiation of cities in terms of population within 1–10%. At the same time, only in 9 regions, there is a decrease in the level of uneven distribution of the urban population. *Table 3* presents a list of regions with the greatest increase in the level of differentiation of cities and regions, in which this indicator decreased over the period under review.

As a result of the analysis, several groups of regions were identified, which are characterized by different patterns of change in the Lorenz coefficient for the period under consideration. These are the regions in which the growth of this indicator took place, i.e. increased unevenness of urban settlement (positive values); regions in which there is a decrease in the indicator — a decrease in the

[10] Rosstat (2021). The population of the Russian Federation by municipalities. 2011–2019 Official site of the Russian Statistical Agency. URL: https://rosstat.gov.ru/compendium/document/13282 (accessed on 22.03.2021).

Table 3

List of regions with the most significant dynamics of the Lorenz coefficient

Region (dynamics of the Lorenz coefficient for 2012–2020)	Population growth by city type (% of cases)					
	Over 1 million people	500 thousand people – 1 million people	250–500 thousand people	100–250 thousand people	50–100 thousand people	Under 50 thousand people
Regions with an increase in the level of differentiation of urban settlement						
Amur region (10%)	–	100	100	67	50	40
Sakhalin region (9%)						
Tyumen region (9%)						
Kemerovo region (8%)						
Republic of Khakassia (8%)						
Krasnodar region (7%)						
Republic of Karelia (7%)						
Khanty-Mansi Autonomous Okrug — Ugra (7%)						
Republic of Buryatia (6%)						
Republic of Mordovia (6%)						
Regions with a decrease in the level of differentiation of urban settlement						
Kabardino–Balkar Republic (–1%)	–	–	–	50	43	56
Yamalo–Nenets Autonomous Okrug (–1%)						
Novgorod Region (–1%)						
Republic of North Ossetia — Alania (–1%)						
Komi Republic (–2%)						
Karachay–Cherkess Republic (–2%)						
Chechen Republic (–3%)						
Murmansk Region (–4%)						
Republic of Ingushetia (–10%)						

Source: compiled by the authors.

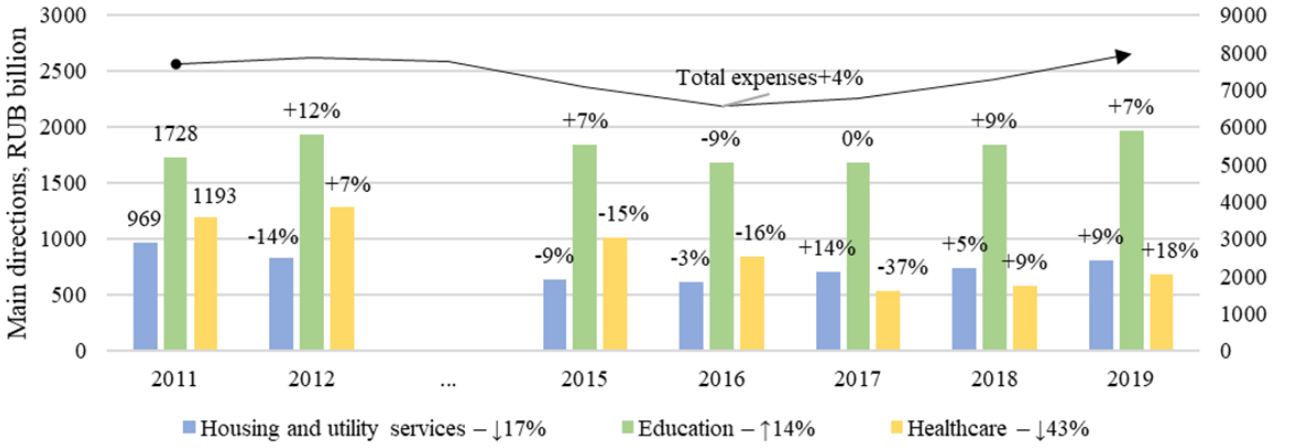

Fig. 6. **Dynamics of expenditures of the consolidated budget of Russia for the period 2011–2019 in 2011 prices**

Source: compiled by the authors based on data of the Federal State Statistics Service. URL: https://rosstat.gov.ru/folder/210/document/13206 (accessed on 22.03.2021).

level of the unevenness of urban settlement (negative values); in other regions, the dynamics of the values of this coefficient ranges from 0 to 3%.

In general, based on the dynamics of the Lorenz coefficient, some features can be identified for different groups of regions. For the subjects in which there is an increase in the uneven distribution of the population, depopulation, and loss of demographic stability of small and medium-sized cities are characteristic. Moreover, for example, the emergence in the Amur Region of a new small city, Tsiolkovsky, did not improve the situation. At the same time, there is an increase in the share of the population living in other categories of cities.

At the same time, the regions in which there is a decrease in the degree of uneven distribution of the population are characterized by lower rates of decline in the share of the population living in small medium-sized cities. Only in 50% of cases there is an increase in the share of the population of large cities with a population of 100 to 250 thousand people. In addition, in all municipalities of this group with a population of 250 to 500 thousand people the share of the population living in this group has decreased.

Thus, the growth in the differentiation of urban settlement is characterized by a high level of depopulation of small and medium-sized cities in most regions, with a contraction and concentration of population in the largest city of the subject, which occurs even despite the emergence of new settlements of this type. In turn, the level of differentiation of urban settlement decreases in the regions in which the decrease in the share of the population of small and medium-sized cities occurs at a slower pace, while the share of the population living in larger cities decreases. These results are largely due to the transition of small cities to the category of medium-sized ones (4 cases). In the Republic of Ingushetia — the transition of a medium-sized city to the category of large and in only one case — the transition of a city to the category of smaller ones. In general, the current situation indicates a decrease in the demographic stability of settlements of this type in Russia.

IMPACT OF SOCIAL INFRASTRUCTURE FINANCING ON DEMOGRAPHIC PROCESSES IN RUSSIA

A significant factor determining the direction and dynamics of demographic processes and, as a consequence, changes in the settlement system, is the level of development of social

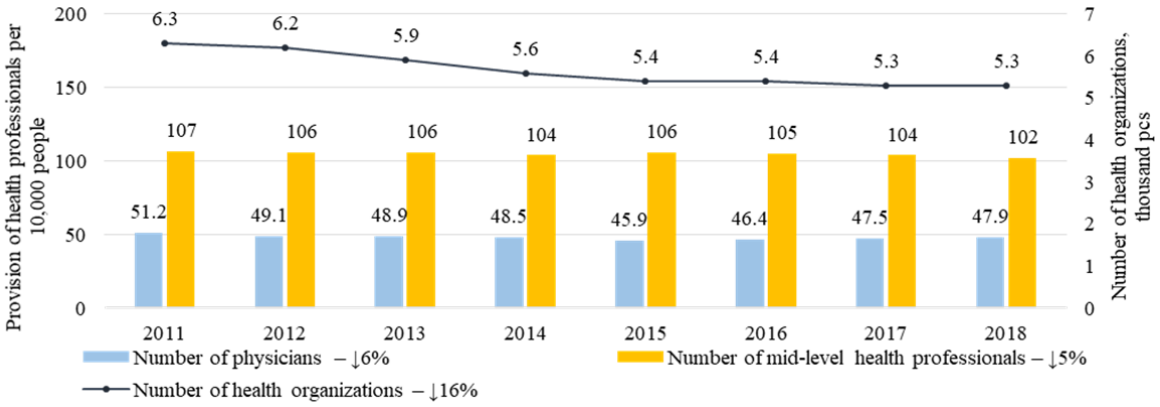

Fig. 7. **Dynamics of the main indicators of the social infrastructure of healthcare in Russia**

Source: compiled by the authors based on data of the Federal State Statistics Service. URL: https://rosstat.gov.ru/folder/210/document/13206 (accessed on 22.03.2021).

infrastructure. It should be noted that the system of financing this sphere in Russia presupposes the priority of the budgetary component. The declared principle of transition to public-private partnership in the development of healthcare and education is currently being implemented rather limitedly. At the same time, the sphere of trade and provision of services, as well as a number of other areas, are significantly developing thanks to private financing.

Consolidated budget expenditures of Russia for 2011–2019 increased by more than one and a half times in actual prices.11 At the same time, expenditures on education almost doubled, and on the housing and utility sector — by 42%. At the same time, healthcare financing decreased by 2%. It is worth noting that a sharp decrease in budget expenditures in this area was observed in the period 2016–2017, which may in part be due to a change in the system of grouping and reflection of expenditures.

It should be noted that the growth in nominal expenditures in most of the areas considered is due to inflationary processes and does not reflect the real situation. To ensure comparability of data, let us consider the dynamics of the values of indicators in prices of the base year, considering the consumer price index (*Fig. 6*).

By 2019, expenses of the consolidated budget of Russia in comparable prices increased by 4%. Expenditures on education during this period increased by 14%. However, there has been a significant reduction in real government spending in areas such as the housing and utility services (–17%) and healthcare (–43%). Such dynamics affect demographic processes and, as a consequence, the settlement system, but their influence in most cases "stretches" over time. Thus, changes in the level of availability of high-quality health care services affect life expectancy. According to the report of the Ministry of Health of the Russian Federation, its value in 2020 decreased by 1.84 years, to 71.5 years. This is largely due to an 18% increase in mortality compared to the 2019 level.12 In absolute terms, it is 323.8 thousand people, which corresponds to the number of 16 average small cities in the country.

The graph shows the dynamics of healthcare indicators, showing the total changes in% (*Fig. 7*).

During the period under review, the provision of the population with health

[11] Ministry of Finance of the Russian Federation. 2021. URL: https://roskazna.gov.ru/ispolnenie-byudzhetov/konsolidirovannye-byudzhety-subektov/974/ (accessed on 22.03.2021).

[12] Rosstat (2021). Regions of Russia. 2019. URL: https://rosstat.gov.ru/bgd/regl/b19_14p/Main.htm (accessed on 22.03.2021).

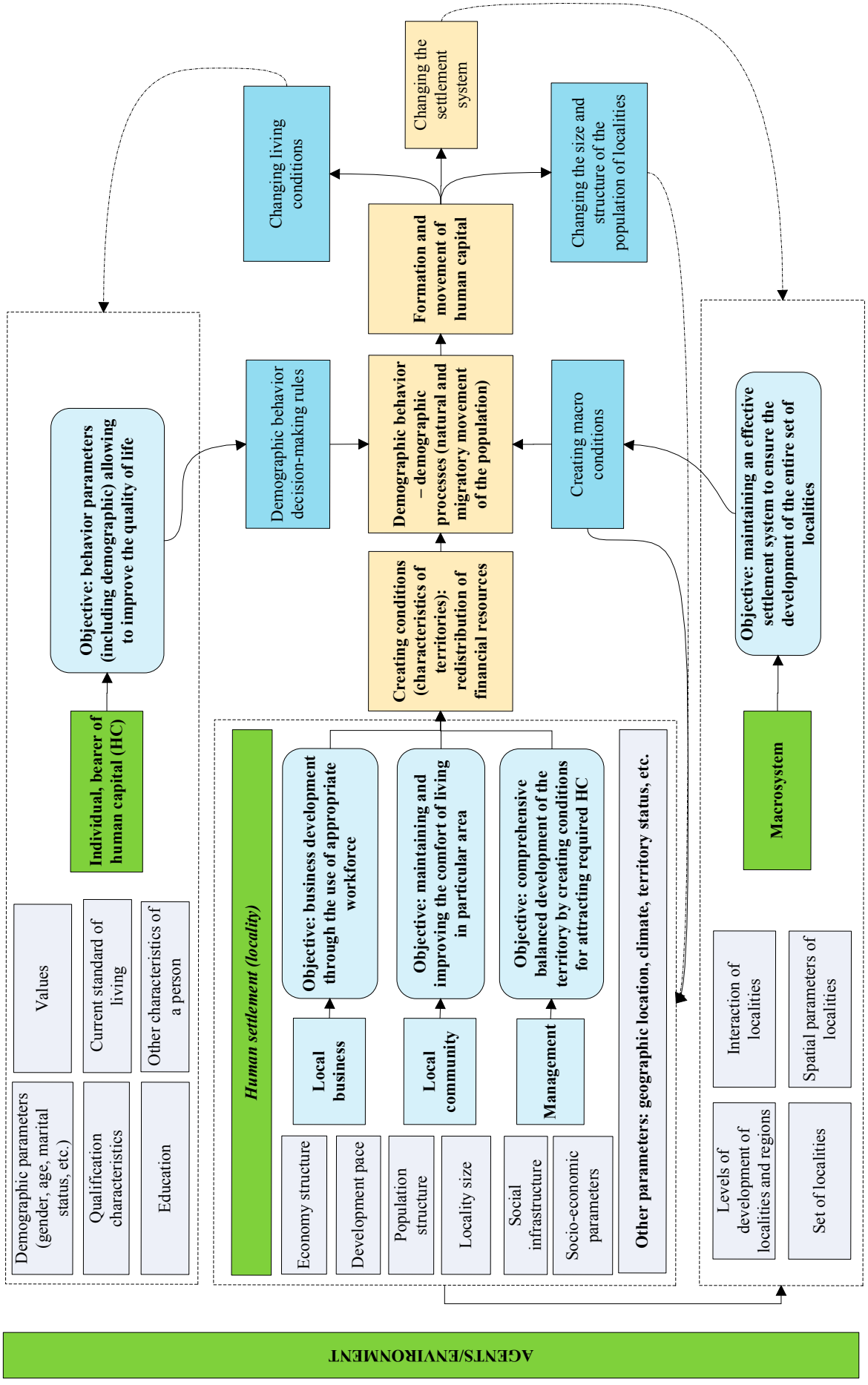

Fig. 8. **Conceptual flowcharts of the agent-based model of the urban settlement system**
Source: compiled by the authors.

professionals and hospital organizations decreased. The Pearson correlation coefficient between these indicators and budgetary health spending at comparable prices is 0.77 and 0.83, respectively, indicating a significant relationship. However, the full impact of these changes on the settlement system will manifest itself only in a few years or even decades.

It should be noted that the real financing of social infrastructure in Russia is characterized by rather contradictory trends. An even more obvious imbalance between resource provision and the development of this direction is observed at the regional level. To solve the problem of assessing the compliance of the level of funding with the result obtained, the regions were grouped according to indicators of the development of healthcare, education, and housing and utility services. As part of the study, the amount of funding and the level of development of these areas (in specific conditions) were correlated with the average Russian values. When comparing the data for the three regions under consideration, a number of regions were identified, which in all cases were attributed to the same groups. Thus, St. Petersburg, the Republic of Tatarstan, and the Yaroslavl region are characterized by a combination of relatively high values of both indicators of the development of social infrastructure and its financing. It is not surprising that this was reflected in the dynamics of demographic processes (for example, in the Leningrad Region, the increase in migration in 2019 was 204 people per 10 thousand population).

The group with a similar level of development of social infrastructure, but with a low level of funding includes Chelyabinsk, Oryol, Ryazan, Tambov, Voronezh, Orenburg, Saratov, Bryansk regions.

Regions with a low level of development of social infrastructure and a high level of funding include the Republic of Komi and Karelia, Krasnoyarsk and Kamchatka Territories, Arkhangelsk, Murmansk, Kemerovo, and Amur Regions, Chukotka Autonomous Okrug, and the Jewish Autonomous Oblast.

Volgograd, Kurgan regions and the Republic of Dagestan are characterized by a low level of development and financing of social infrastructure.

Thus, these are not just special cases of imbalance in resource provision and the results obtained, but a certain stable characteristic of the region in terms of the effectiveness of the measures being implemented. Solving the problems of effective allocation and use of financial resources of the state for the creation of social infrastructure and, in general, the implementation of measures to regulate the processes of changing the settlement system requires a search for best practices. It should be noted that the development of regions and cities is influenced by a complex of dissimilar factors, and therefore, to improve the situation, an integrated approach is also required, the implementation of which requires the use of modern formalized methods of analysis and forecasting.

CONCEPTUAL APPROACH TO FORMATION OF THE URBAN PAYMENT SYSTEM

Currently, the uneven distribution of the urban population across the country continues to increase, which is also manifested at the regional level. These circumstances are due to various factors, including a high degree of differentiation of territorial entities in terms of socio-economic development, the financial security of both the population and regional budgets, climatic conditions, geographical location, etc. [20]. These factors form a multitude of overlapping heterogeneous influences that affect the demographic behavior of the population as a whole and each person individually. The complexity of this situation does not allow to fully reflect all its components when using expert methods of analysis and

assessment of possible directions for the development of the settlement system in Russia. In this regard, the task of forming tools for supporting decision-making is being actualized, and, first of all, developing a set of economic and mathematical models that could be considered as the core of such tools. This approach makes it possible to increase the effectiveness of public policy measures in the area under consideration by building scientifically based scenario forecasts of the consequences of their implementation. Based on the specifics of the problem under consideration, the most promising is the use of the agent-based approach [21–23]. The concept of forming a model of a settlement system developed within the framework of the study considers it as a set of interacting subsystems-agents. Undoubtedly, the main agents in the settlement model are the settlements and the population, between which various relationships are built taking into account economic, social, demographic, climatic, and other processes. At the same time, within the framework of the proposed model, special attention is paid to the formation of monetary incomes of the population and financing of social facilities. It should be emphasized that from the point of view of state regulation of the processes of formation of the settlement system, in fact, we are talking about the redistribution of financial resources between individual events, departments, and territories. *Fig. 8* shows a conceptual diagram of a model of demographic processes from the point of view of the formation of a settlement system.

The key agent within the framework of the proposed model is "Individual", which has many diverse characteristics that can be grouped in such areas as value orientations, demographic characteristics, qualifications, educational level, etc. All these parameters in one way or another determine the demographic behavior of a person including his propensity to create a family, attitude towards raising children, the desired number of children, the propensity to change their place of residence, as well as the likelihood of death at a given age. It should be noted that within the framework of the formed model, the demographic behavior of a person is considered as an integral part of a more complex system, including, among other things, his financial, labor, social, and other behavior [24]. In this case, the target task of this agent within the framework of the developed model is to determine such parameters of his behavior that would improve the quality of life of the individual and his household.

At the same time, solving the problem of modeling the processes of forming a settlement system and assessing the demographic stability of a territory is impossible without considering the parameters of the territories, in this case, cities. To describe the characteristics of these agents, it is necessary to take into account the multiplicity of their interests, since settlements are considered not so much geographically as socio-economically. This predetermines the need to reflect cities as an aggregate of the population living in them, the business located on their territory, and the local authorities that govern them. Thus, the set of characteristics of settlements includes parameters that describe the structure of the economy (including the number of employees and levels of wages by type of economic activity), the structure of the population (as a set of agents of "Individual" type), parameters for the development of social infrastructure, financial characteristics such as the level of household income, the level of prices, the volume of income and the structure of expenditures of the budget of the territory, the financial indicators of the enterprise and organization, their investment policy, etc. In addition, such characteristics of cities are considered that, within the framework of the built model, are unchanged and uncontrollable, for example, geographic

location, climate, etc. These characteristics and the results of the action of the "Human settlement" agent determine the living conditions in the territory that are influenced by the decision-making by the "Individual" agent in the region of its demographic behavior.

In addition, the external environment, which in this case is a macrosystem, has a certain impact on the development and behavior of both of the above agents. It should be noted that within the framework of the proposed model, it was not considered as a separate agent, and its parameters are set by scenario conditions, however, *Fig. 8* shows the conceptual idea embodied in its description.

Thus, the interaction of agents in the model and their characteristics determine the demographic behavior of the population and form demographic processes (both in terms of natural and migratory movement of the population). This leads not only to a multitude of reactions of individual agents of the "Individual" type but to the formation and spatial movement of human capital and the adjustment of the settlement system in the country. As feedback, there is a change in the living conditions of each of the agents of the "Individual" type and the characteristics of settlements. It should be noted that the territorial level of modeling can cover a set of cities in a region or the country as a whole, based on the goals of modeling. The developed approach to the model of the settlement system, considering the mutual influence of dissimilar factors and processes as a result of the implementation, will determine the dynamics, trends of settlement and develop a forecast of changes in the demographic stability of a territorial entity. The modeling results, in turn, provide for the possibility of developing the main measures and directions to improve the situation by creating conditions for the socio-economic development of the territory with various directions of state policy.

CONCLUSIONS

At present, the system of urban settlement in Russia is characterized by an uneven population distribution over the territory of the country, which is due to historical, geographical, climatic features, but at the same time socio-economic conditions. The latter, in turn, are more amenable to government regulation. The results of the analysis based on the calculations of the Lorenz coefficient indicate an increase in the differentiation of cities in terms of population in the regions of the country, which is expressed in an increase in the unevenness of the spatial population distribution across the territory of subjects. These trends are due to the processes of population reduction and concentration in large cities of the country, a high migration outflow of the population from small and medium-sized cities, as a result of which the differentiation of cities increases, the threat of depopulation of the space between the largest municipalities are being created, the load on the social infrastructure of such cities is increasing, and the risks of instability of development of territories are formed.

In this regard, it becomes important to determine the priorities and directions of regulation of the spatial population distribution. Despite the existence in Russia of developed regulatory documents in the field of the territorial organization of the population, a number of aspects still require the attention of federal authorities. An important decision could be the development of a federal document in the field of regulation of the settlement system, within the framework of which the main position of the state on resolving the current situation will be indicated. The most effective and convenient tool for determining the directions of state regulation in these conditions can be a model developed based on an agent-based approach. Its application will allow, among other things, to justify the feasibility of redistributing financial

resources of the budget to ensure state policy in the development of the settlement system in the country.

The basis of the federal policy in the field of spatial settlement should be the interconnected development of municipalities, including an increase in the convenience of using inter-municipal territories in combination with the development of individual settlements. At the same time, an integrated approach is needed on the part of government bodies based on considering the interests of all types of cities, including within the framework of the Strategy for the Spatial Development of Russia.

ACKNOWLEDGEMENTS

Research is supported by the RFBR, No. 20–010–00783. Financial University, Moscow, Russia; No. 075-00504-21-00 Institute of Social and Economic Researches of the Ufa Federal Research Center of the Russian Academy of Sciences, Ufa, Russia.

REFERENCES

1. Krasnoselskaya D. et al. Determination of capital accumulation in region using benchmarking tool. *Espacios*. 2019;40(35):1–8. URL: https://www.revistaespacios.com/a19v40n35/a19v40n35p18.pdf
2. Bashirov V. R. Actualization methods of Russian population settlement mapping as exemplified by Southern Russia population map. *Izvestiya vysshikh uchebnykh zavedenii. Geodeziya i aerofotos"emka = Izvestia VUZov. Geodesy and Aerophotosurveying*. 2017;(2):51–55. (In Russ.).
3. Fedyakin I. V. Metropolitan megacities in the territorial and political structure of the state: Historical experience. *Vestnik Rossiiskoi natsii = Bulletin of Russian Nation*. 2011;(1–2):284–291. (In Russ.).
4. Leksin V. N. Settlement system crisis in connection with radical transformation of spatial organization of Russian society. *Rossiiskii ekonomicheskii zhurnal = Russian Economic Journal*. 2012;(1):3–44. (In Russ.).
5. Mavlyutov E. F., Yusin G. S., Raev Yu. V. Prerequisites of the "Doctrine of spatial development of the settlement system of the Russian Federation up to 2025". Moscow: The Government of Moscow; 2011. 39 c. URL: https://genplanmos.ru/static/uploads/files/files/doctrina_2025.pdf (In Russ.).
6. Tkachenko A. A. Key concepts of the settlement theory: An attempt of rethinking. *Vestnik Moskovskogo universiteta. Seriya 5. Geografiya = Moscow University Bulletin. Series 5. Geography*. 2018;(2):10–15. (In Russ.).
7. Krupko A. Systemic-structural approach in the study of population and settlement. *Vestnik Voronezhskogo gosudarstvennogo universiteta. Seriya: Geografiya. Geoekologiya = Proceedings of Voronezh State University. Series: Geography. Geoecology*. 2002;(1):70–73. (In Russ.).
8. Kudryavtsev O. K. Settlement and planning structure of large cities-agglomerations. Moscow: Stroiizdat; 1985. 136 p. (In Russ.).
9. Khodzhaev D. G., Khorev B. S. The concept of a unified settlement system and planned regulation of urban growth in the USSR. In: Urbanization problems in the USSR. Moscow; 1971:19–31. (In Russ.).
10. Dumenton G. G., Lezhava I. G. On ways to new expansion of the population in Russia at transition to the information society based on combinations of the science and technicians. *Architecture and Modern Information Technologies*. 2012;(4):7. (In Russ.).
11. Mazaev A. Main characteristics of the optimized national settlement system of the Russian Federation. *Akademicheskii vestnik UralNIIproekt RAASN*. 2018;(4):16–21. (In Russ.).
12. Aitova J. S. Analysis of the Russian Federation's policy in regulation of demographic processes. *Vestnik Evraziiskoi nauki = The Eurasian Scientific Journal*. 2019;11(6):2. (In Russ.). DOI: 10.15862/26ECVN 619
13. Josic H., Bašić M. Reconsidering Zipf's law for regional development: The case of settlements and cities in Croatia. *Miscellanea Geographica*. 2018;22(1):22–30. DOI: 10.2478/mgrsd-2018–0002
14. Manaeva I. V., Kanishcheva A. V. The Zipf's law: A cross-country analysis. *Ekonomicheskii analiz: teoriya i praktika = Economic Analysis: Theory and Practice*. 2018;17(7):1337–1351. (In Russ.). DOI: 10.24891/ea.17.7.1337

15. Chen Y. The evolution of Zipf's law indicative of city development. *Physica A: Statistical Mechanics and its Applications*. 2016;443:555–567. DOI: 10.1016/j.physa.2015.09.083
16. Fattakhov R. V., Nizamutdinov M. M., Oreshnikov V. V. Analysing and modelling of trends in the development of the territorial settlement system in Russia. *Ekonomika regiona = Economy of Region*. 2019;15(2):436–450. (In Russ.). DOI: 10.17059/2019–2–10
17. Fattakhov R. V., Nizamutdinov M. M., Oreshnikov V. V. Assessment of the attractiveness of large Russian cities for residents, tourists, and business. *Regional Research of Russia*. 2020;10(4):538–548. DOI: 10.1134/S 2079970520040036
18. Veneri P. City size distribution across the OECD: Does the definition of cities matter? *Computers, Environment and Urban Systems*. 2016;59:86–94. DOI: 10.1016/j.compenvurbsys.2016.05.007
19. Gorin N., Nechshadin A., Soskova O. The tools of measurement of differentiation of urban settlement. *Obshchestvo i ekonomika = Society and Economy*. 2014;(2–3):241–247. (In Russ.).
20. Zhahov N., Alpeeva E., Krivoshlykov V., Nesenyuk E. Inevitability of structural and economic reforms of regional economy. In: Proc. 33rd Int. Business Information Management Association conf. (IBIMA-2019). (Granada, Apr. 10–11, 2019). King of Prussia, PA: IBIMA; 2019:4392–4397.
21. Grow A., van Bavel J., eds. Agent-based modelling in population studies: Concepts, methods, and applications. Cham: Springer International Publishing; 2017. 513 p. (The Springer Series on Demographic Methods and Population Analysis. Vol. 41). DOI: 10.1007/978–3–319–32283–4
22. Silverman E. Methodological investigations in agent-based modelling: With applications for the social sciences. Cham: Springer International Publishing; 2018. 235 p. (Methodos Series. Vol. 13). DOI: 10.1007/978–3–319–72408–9
23. Reinhardt O. et al. Streamlining simulation experiments with agent-based models in demography. *Journal of Artificial Societies and Social Simulation*. 2018;21(3):9. DOI: 10.18564/jasss.3784
24. Nizamutdinov M. M., Oreshnikov V. V. Issues of regulating economic agents behavior in territorial development management. *Upravlencheskie nauki = Management Sciences in Russia*. 2018;8(3):74–87. (In Russ.). DOI: 10.26794/2404–022X-2018–8–3–74–87

ABOUT THE AUTHORS

Rafael' V. Fattakhov — Dr. Sci. (Econ.), Prof., Department of Public Finance, Financial University, Moscow, Russia
fattakhov@mail.ru

Marsel' M. Nizamutdinov — Cand. Sci. (Tech.), Assoc. Prof., Head of the Sector of economic and mathematical modelling, Institute of Social and Economic Researches of the Ufa Federal Research Center of the Russian Academy of Sciences, Ufa, Russia
marsel_n@mail.ru

Yuliya S. Aitova — Junior Researcher of the Sector of economic and mathematical modelling, Institute of Social and Economic Research of Ufa Federal Research Center, Russian Academy of Sciences, Ufa, Russia
yushaaitova@gmail.com

Vladimir V. Oreshnikov — Cand. Sci. (Econ.), Senior Researcher of the Sector of economic and mathematical modelling, Institute of Social and Economic Research of Ufa Federal Research Center, Russian Academy of Sciences, Ufa, Russia
voresh@mail.ru

***Authors' declared contributions*:**
Fattakhov R.V. — developed the research methodology, justified the choice of indicators for analysis, interpreted the results.
Nizamutdinov M.M. — reviewed the existing approaches to the problem under study, wrote the conclusions and recommendations based on the results.
Aitova Yu.S. — performed a comprehensive analysis, constructed Zipf and Lorenz curves, evaluated social infrastructure financing, designed tabular and graphical representations of the results.
Oreshnikov V.V. — performed statistical data analysis, developed proposals for the formation of the economic and mathematical model.

The article was submitted on 24.05.2021; revised on 10.06.2021 and accepted for publication on 27.06.2021.
The authors read and approved the final version of the manuscript.